INTEGRATED PROTOCOL FOR GROUND AND STRUCTURES CONDITION ASSESSMENTS USING AMBIENT VIBRATION

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ABSTRACT

Safety and serviceability issues on ground or structure normally arise after deterioration or damage appearances. It is worst when there is no regular maintenance program or complete engineering record to carry out the re-evaluation work. Application of ambient vibration (AV) technique is widely used on ground and structures diagnosis works, but none of an effort to integrate them into a specific protocol. The main goal of this thesis is to develop a robust integrated condition assessment protocol on ground and structure using ambient vibration and the main assessment parameter of origin natural frequency. AV testing was performed using a tri-axial seismometer on ground and reinforced concrete (RC) school buildings, with different geotechnical profiles, building configurations and structural health conditions. Determination of peak natural frequency was computed based on the popular methods of Horizontal to Vertical Spectral Ratio (HVSR) and Fourier Amplitude Spectra (FAS) via GEOPSY software. Started by ground condition assessment protocol, the soil classification, soil thickness, and microzonation maps were determined for local soil condition. Meanwhile, in structural condition assessment protocols, the evaluations were made on rocking effect, soil-structure resonance, structural health monitoring (SHM), and building vulnerability. The analysis was initiated by validation of HVSR method on ground, and verification of FAS method on 4-storey of RC buildings. HVSR has proven to be the reliable method. From repetitive AV measurements had indicated consistent prediction with less than 7.0 % disparity of fundamanetal ground frequency (F_o). FAS method showed 0 % of difference at the first mode of predominant building frequency (f_o) prediction and 9.5 % at the fifth f_o, with the comparison made to prior research. Microzonation map successfully described the sub-surface profile and the resonance zone. Good health of buildings was obtained in repetitive AV measurement within 1.5 years of maximum gap. In rocking effect protocol, the existence of friction piles was clearly identified. Illustrations of mode shapes at respective f_o explained the influence of adjacent building, mass and geometric irregularities. A nomograph was introduced for quick evaluation of several components in the integrated protocols at the end analysis. In conclusion, the developed integrated protocol has demonstrated a novel, reliable and robust condition assessment. It will benefit to any ground and comparable RC building even without complete engineering database.

ABSTRAK

Isu keselamatan dan kebolehkhidmatan tanah dan struktur kebiasaaan timbul selepas berlakunya kemerosotan atau kerosakan. Lebih diburukkan apabila tiada program penyelenggaraan berkala dan rekod kejuruteraan lengkap untuk proses penilaian semula. Aplikasi teknik getaran (AV) ambien digunakan secara meluas dalam kerja-kerja diagnosis tanah dan stuktur. Namun tiada usaha menyatupadukannya ke bentuk protokol yang lebih spesifik. Matlamat tesis ini ialah untuk membangunkan sebuah protokol mapan penilaian keadaan bersepadu ke atas tanah dan struktur menggunakan teknik getaran ambien dan parameter utama frekuensi tabii. Ujian AV dijalankan menggunakan pengesan seismometer 3-paksi ke atas beberapa kawasan tanah dan bangunan sekolah konkrit bertetulang (RC) yang berbeza profil geoteknik, konfigurasi bangunan dan keadaan kesihatan struktur. Penentuan puncak frekuensi tabii dikira berdasarkan kaedah popular Nisbah Spektrum Mengufuk-Menegak (HVSR) dan Spektrum Fourier Amplitud (FAS) melalui perisian GEOPSY. Bermula dengan protokol penilaian keadaan tanah, pengkelasan tanah, ketebalan tanah dan peta mikrozonasi ditentukan dalam penyiasatan keadaan tanah tempatan. Sementara itu, pada protokol penilaian keadaan struktur, penilaian dilakukan terhadap kesan goyangan, resonan tanah-struktur, pemantauan kesihatan struktur (SHM), dan kelonggaran bangunan. Analisis dimulakan dengan pengesahan kaedah HVSR di tapak yang dikenalpasti, dan pengesahaan kaedah FAS bangunan-bangunan RC 4-tingkat. Terbukti kaedah HVSR boleh dipercayai. Berdasarkan pengukuran AV ulangan menunjukkan ramalan kosisten dengan peratusan perbezaan frekuensi asas tanah (F_o) sebanyak 7.0 %. Kaedah FAS menunjukkan 0 % perbezaan pada frekuensi dominan bangunan (f_o) pertama dan 9.5 % pada f_o kelima melalui perbandingan yang dilakukan pada penyelidikan lepas. Peta mikrozonasi berjaya menjelaskan profil sub-permukaan dan zon resonan. Kesihatan bangunan yang baik juga diperolehi dalam pengukuran ulangan AV. Dalam protokol kesan goyangan, kewujudan cerucuk geseran jelas dikenalpasti. Ilustrasi ragam bentuk pada keadaan mod f_o masing-masing menjelaskan faktor pengaruh bangunan bersebelahan, ketidakseragaman jisim dan geometri. Sebuah nomograf diperkenalkan untuk penilaian cepat beberapa komponen dalam protokol bersepadu ini di akhir analisis. Sebagai kesimpulan, protokol integrasi yang dibangunkan merupakan sebuah kaedah penilaian yang baharu, mantap dan boleh dipercayai. Ia boleh dimanfaatkan terhadap kawasan tapak dan bangunan RC seumpamanya, walaupun dengan rekod pengkalan data kejuruteraan yang tidak lengkap.

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